CLAIMS

Having thus described the aforementioned invention, we claim:

1. A proximity monitoring system capable of accurate boundary detection that is substantially independent of orientation, said proximity monitoring system comprising:

a transmitter including at least one antenna array, said transmitter generating an electrical signal, said transmitter antenna array continuously generating a magnetic field based on said electrical signal, said magnetic field having an intensity and defining a boundary; and

a receiver module including an antenna array responsive to said magnetic field in electrical communication with a single channel receiver and a measurement circuit for determining a total power of said magnetic field incident at said antenna array.

2. The proximity monitoring system of Claim 1, wherein said boundary is a locus of all points proximate ground level on a path surrounding said transmitter at a predetermined said magnetic field intensity.

3. The proximity monitoring system of Claim 1 wherein said transmitter at least one antenna array includes a first transmitter antenna representing a first coordinate axis, a second transmitter antenna representing a second coordinate axis, and a third transmitter antenna representing a third coordinate axis.

4. The proximity monitoring system of Claim 3 wherein said magnetic field is a composite magnetic field summing a first magnetic field component from said first transmitter antenna, a second magnetic field component from said second transmitter antenna, and a third magnetic field component from said third transmitter antenna.

5. The proximity monitoring system of Claim 4 wherein each of said first magnetic field component, said second magnetic field component, and said third magnetic field component is continuously transmitted using a single carrier frequency.

6. The proximity monitoring system of Claim 5 wherein said single carrier frequency is uniquely modulated for each of said first magnetic field component, said second magnetic field component, and said third magnetic field component.

7. The proximity monitoring system of Claim 5 wherein said single carrier frequency is a programmable integral multiple of a power supply line frequency.

8. The proximity monitoring system of Claim 5 wherein said single carrier frequency is derived from a crystal oscillator using a phase locked loop.

9. The proximity monitoring system of Claim 5 wherein said single carrier signal is modulated using a binary phase shift keying waveform.

10. The proximity monitoring system of Claim 9 wherein a coherent said binary phase shift keying waveform is modulated using a waveform produced by integral ratio frequency division of a transmitter system clock.

11. The proximity monitoring system of Claim 9 wherein said binary phase shift keying waveform is selected to produce a high degree of rejection of interference at a power line frequency and any significant harmonics of the power line frequency and to allow accurate decomposition of said composite magnetic field into said first magnetic field component, said second magnetic field component, and said third magnetic field component.

12. The proximity monitoring system of Claim 3 wherein said first transmitter antenna, said second transmitter antenna, and said transmitter third antenna are constructed using antenna coils having substantially similar dimensions.

13. The proximity monitoring system of Claim 3 wherein one of said first transmitter antenna, said second transmitter antenna, and said transmitter third antenna is constructed from a pair of said antenna coils.

14. The proximity monitoring system of Claim 1 wherein said receiver antenna array includes a two-axis, single output magnetic field sensing antenna producing a single magnetic field transduction signal output.

15. The proximity monitoring system of Claim 1 wherein said receiver is a non-multiplexed, single channel receiver.

16. The proximity monitoring system of Claim 14 wherein said receiver is fabricated on a single integrated circuit including an input amplifier, an I and Q baseband converter, a phase locked loop, a crystal oscillator, a baseband pass filter, and an I and Q baseband amplifier.

17. The proximity monitoring system of Claim 16 wherein said receiver further includes a baseband sigma delta modulator for producing an I and Q bit stream.

18. The proximity monitoring system of Claim 17 wherein said receiver further includes a sigma delta converter digital filter for sampling said I and Q bit stream down to a sampling frequency that is nominally equivalent to twice a power line frequency.

19. The proximity monitoring system of Claim 16 wherein said I and Q baseband converter is a switching mixer.

Sub B4 20. The proximity monitoring system of Claim 16 wherein said receiver further includes an analog-to-digital converter in electrical communication with said I and Q baseband converter, said stimulus module further comprising a digital signal processor in electrical communication with said analog-to-digital converter, said analog-to-digital converter producing an digital I and Q baseband signal from an output of said I and Q baseband converter.

21. The proximity monitoring system of Claim 20 wherein said digital signal processor extracts each of said first magnetic field component, said second magnetic field component, and said third magnetic field component from said digital I and Q baseband signal.

Sub B5 22. The proximity monitoring system of Claim 21 wherein said receiver module is carried by a pet, said receiver module further comprising a stimulus delivery system for applying a deterrent stimulus to the pet when the pet approaches said boundary.

23. The proximity monitoring system of Claim 16 wherein said receiver includes detection logic to detect an unusually rapid decrease in said total power of said magnetic field incident at said antenna array thereby indicating a loss of power to said transmitter.

24. A method for forming a measure of a component of a modulated composite magnetic field broadcast by a transmitter in a wireless pet containment system without requiring a receiver data acquisition clock to be synchronized with a transmitter modulation clock, said method comprising the steps of:

(a) sampling a modulated composite magnetic field to produce a

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plurality of I and Q samples;

(b) correlating a plurality of successive said I and Q samples with a first predetermined sequence to produce a first measure of I and Q; and

(c) correlating said plurality of successive I and Q samples with a second predetermined sequence to produce a second measure of I and Q.

25. The method of Claim 24 wherein said first predetermined sequence is defined as {+1, +1, +1, +1, -1, -1, -1, -1} and said second predetermined sequence is defined as {-1, -1, +1, +1, +1, +1, -1, -1}.

26. A method for synchronizing a receiver data acquisition clock with a phase of a modulated magnetic field in a wireless pet containment system including a transmitter connected to an power supply voltage having a frequency, said method comprising the steps of:

(a) selecting one of at least three unique divisor factors such that said sampling clock has a frequency selected from the group consisting of at least a frequency less than twice the power supply voltage frequency, a frequency greater than twice the power supply voltage frequency, and a frequency equivalent to twice the power supply voltage frequency as a selected divisor factor;

(b) deriving a sampling clock from a system clock using said selected divisor factor;

(c) correlating a plurality of I and Q samples with a selected sequence to produce a measure of I and Q;

(d) holding said divisor factor constant during said step of correlating a plurality of I and Q samples such that all said measures of I and Q in a given correlation result set are acquired at the same sampling clock frequency;

(e) setting said divisor factor to a frequency less than twice the power supply voltage frequency when a second said measure of I and Q is less than a first said measure of I and Q;

(f) setting said divisor factor to a frequency greater than twice the power supply voltage frequency when a second said measure of I and Q is at

least as great as a first said measure of I and Q; and

(g) locking a receiver data acquisition clock to a phase of a first magnetic field component that is transmitted at a modulation rate equal to one-half of the power supply voltage frequency and is in phase quadrature with a second magnetic field component that is also in phase alignment with a third magnetic field component transmitted at a modulation rate equal to one-quarter of the power supply voltage frequency.

27. The method of Claim 26 wherein said divisor factor is set equal to the frequency equivalent to twice the power supply voltage frequency when excessive I or Q zero crossings are detected.

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28. A proximity monitoring system capable of accurate boundary detection that is substantially independent of orientation, said proximity monitoring system comprising:

a transmitter including at least one antenna array, said transmitter generating an electrical signal, said transmitter antenna array continuously generating a magnetic field based on said electrical signal, said magnetic field having an intensity and defining a boundary, said transmitter connected to a power supply line having a frequency; and

a receiver module including an antenna array responsive to said magnetic field in electrical communication with a receiver, a measurement circuit for determining a total power of said magnetic field incident at said antenna array, and a digital signal processor for extracting components of said magnetic field and rejecting interference induced from said power supply line frequency.